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NATIONAL DAM SAFETY PROGRAM. HOLLY LAKE DAM (MO 11021), MISSOUR--ETC(U)
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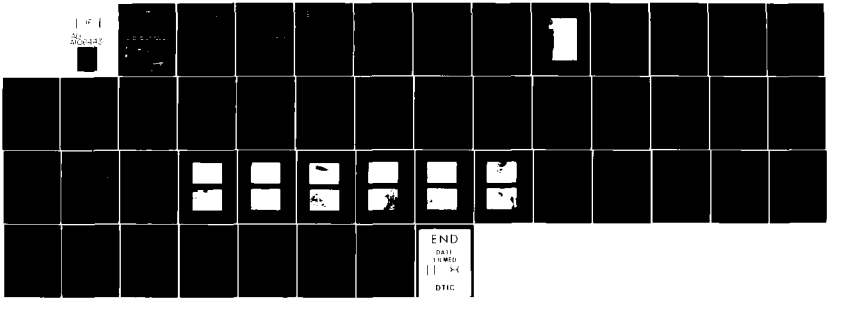

LEVEL II

MISSOURI-KANSAS CITY BASIN

HOLLY LAKE DAM

CLAY COUNTY, MISSOURI

MO 11021

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT. ST. LOUIS

FOR: STATE OF MISSOURI

MAY 1980

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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MISSOURI-KANSAS CITY BASIN

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PHASE 1 INSPECTION REPORT
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PREPARED BY: U.S. ARMY ENGINEER DISTRICT. ST. LOUIS

FOR: STATE OF MISSOURI

MAY 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Holly Lake Dam, MO. I.D. No. 11021
Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Holly Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: _____ _____
Chief, Engineering Division Date

APPROVED BY: _____ _____
Colonel, CE, District Engineer Date

HOLLY LAKE DAM

CLAY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 11021

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

MAY 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Holly Lake Dam
State Located	Missouri
County Located	Clay County
Stream	Tributary to Little Shoal Creek
Date of Inspection	8 May 1980

Holly Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and were developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten lives and property. The estimated damage zone extends approximately three miles downstream of the dam. Within the estimated damage zone are twenty-two homes, two highways, four buildings, a nursing home, a shopping center, a sewage disposal pond, and a railroad. Contents of the estimated downstream damage zone were verified by the inspection team.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass the probable maximum flood without overtopping but will pass 15 percent of the probable maximum flood. The spillway will pass the estimated one percent probability flood without overtopping (100-year flood). The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the downstream hazard, the spillway design flood should be 100 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.

Based on visual observations, this dam appears to be in fair to poor condition. Deficiencies visually observed by the inspection team were erosion on the front face of the dam, trees on both the front and back faces, ruts and potholes on the crest, a few animal burrows, seepage in the creek channel downstream of the dam, and holes in the front face caused by people digging for fishing worms. Seepage and stability analyses required by the guidelines were not available.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

Paul R. Zaman, PE
Illinois 62-29261

Edwin R. Burton, PE
Missouri E-10137

Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HOLLY LAKE DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Holly Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure located in the valley of a tributary to Little Shoal Creek (see Plate 1). The watershed area is hilly consisting of forested area and a small urban area at the upstream end. The dam is approximately 605 feet in length as measured along the crest and 34 feet high. The dam crest is 12 feet wide. The downstream face of the dam has a varied slope from the crest to the valley floor below.

(2) The primary spillway from the lake is an uncontrolled 13-inch welded steel pipe with a canopy inlet installed in the embankment. The canopy is formed by a barrel lid welded to the top of the pipe for vortex control. The beveled outlet pipe is curved upward from the lower end. The pipe acts as an orifice. Flow through the pipe discharges into the natural stream channel below. There is no emergency spillway.

(3) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in southern Clay County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Kearney SW, Missouri in Section 1 of T51N, R32W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Holly Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Holly Lake Dam the estimated flood damage zone extends approximately three miles downstream of the dam. Within the estimated damage zone are twenty-two homes, two highways, four buildings, a nursing home, a shopping center, a sewage disposal pond, and a railroad. Contents of the estimated downstream damage zone were verified by the inspection team.

e. Ownership. The dam is owned by Mr. Holly Newton, 710 Ridge, Liberty, Missouri, Telephone 816-842-2746.

f. Purpose of Dam. The dam forms a 6-acre lake used for recreation.

g. Design and Construction History. Construction records were unavailable.

h. Normal Operating Procedure. Normal rainfall, runoff, inflow from springs, transpiration, evaporation, seepage from the reservoir, and overflow through the uncontrolled outlet pipe all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 81 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled 13-inch outlet pipe.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation 21 cfs (Probable Maximum Flood Pool El.934.3).

c. Elevation (Feet above m.s.l.).

(1) Top of dam - 932.4 (see Plate 3)

(2) Primary spillway pipe invert - 929.0

(3) Streambed at toe of dam - 898.1

(4) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 1,100 feet ± (Probable maximum flood pool level)

(2) Length of normal pool - 1,050 feet ± (Primary spillway pipe invert)

e. Storage (Acre-feet).

(1) Top of dam - 65

(2) Primary spillway pipe invert - 42

(3) Design surcharge - Not available.

f. Reservoir Surface (Acres).

(1) Top of dam - 6.9

(2) Primary spillway pipe invert - 6.3

g. Dam.

(1) Type - Earth embankment

(2) Length - 605 feet

(3) Height - 34 feet ±

(4) Top width - 12 feet

(5) Side slopes - upstream face 1.0 V on 2.4 H, downstream face between 1.0 V on 2.3 H and 1.0 V on 4.2 H (see Plate 4)

(6) Zoning - Unknown.

(7) Impervious core - Unknown.

(8) Cutoff - Unknown.

(9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Primary Spillway.

(1) Type - 13-inch steel pipe with a canopy inlet.

(2) Inlet invert elevation - 929.0 feet m.s.l.

(3) Outlet invert elevation - 899.1 feet m.s.l.

(4) Gates - None.

(5) Upstream channel - Trees and debris in channel.

(6) Downstream channel - Natural open channel to the streambed which runs parallel to the toe of the dam. The streambed is 3-4 feet deep and about 7 feet wide.

j. Emergency Spillway. - None.

k. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design data were available.

2.2 CONSTRUCTION

Construction records were unavailable.

2.3 OPERATION

No operational records or documentation of past floods were available.

2.4 GEOLOGY

The site of the dam and reservoir is located in a deeply dissected valley between two ridges. The dam impounds a small intermittent headwater tributary of Little Shoal Creek.

The soils of the area consist of the Snead rock outcrop complex and the Knox urban complex. The Snead series consists of moderately-deep moderately well-drained soils on hillsides formed in residuum weathered from calcareous clayey shales and thin interbedded limestone. The depth of the rock varies from 15 to 30 inches. The soil is classified for engineering purposes as a CL or CH material. The Knox series consists of deep, well-drained soils formed in thick loess on strongly dissected river hills and bluffs. The depth to rock is greater than 60 inches. The soil is classified for engineering purposes as a CL-ML or CL material.

The bedrock of the area consists of the Bonner Springs formation of the Kansas City Group, and the Plattsburg, Vilas and Stantox formations of the Lansing Group. All rocks are of the Pennsylvanian System. The Bonner Springs formation consists of clayey shale, sandy shale and sandstone. The Plattsburg formation consists of a lower thin limestone member, a middle shale member and an upper thick limestone member. The Vilas formation consists of clayey and sandy shale, and the Stantox formation consists of interbedded limestone and shale members.

The abutments of the embankment are anticipated to be interbedded thin limestone and shale members of the Plattsburg formation over shale of the Bonner Springs formation. The foundation is anticipated to be alluvial soil classified as a CL material overlying shale of the Bonner Springs formation. These interpretations are based on published data.

2.5 EVALUATION

a. Availability. No engineering data were available.

b. Adequacy. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Holly Lake Dam was made on 8 May 1980. The inspection team consisted of Ed Burton, team leader; Bob Pinker, geologist; Gary Van Riessen, geotechnical engineer; John Ruhl, hydrologist; Mark Snyder, hydrologist; and Russ Burnham, structural engineer. Mr. Holly Newton, owner of the dam, was present at the site during the inspection. This dam is in fair to poor condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. The crest of the dam has a sparse grass cover and is rutted from heavy foot and motor bike traffic. There are also several areas of cracking caused by dryness and several potholes on the crest. Both of the embankment slopes are covered with grass and brush. The upstream face has a few small willows approximately 1 inch in diameter. The downstream face is covered with trees up to 12 inches in diameter. The upstream face, which has no riprap, has been eroded at the waterline to form a berm and a 1-1/2 foot vertical drop. An area of erosion, about 3 feet across, exists on the downstream face of the embankment. The material being eroded is a clayey silt (CL). There is another area of minor erosion near the top of the downstream face. Holes on the upstream face are evidence that the embankment has been used to dig for fishing worms. The only seepage observed is in the creek channel below the dam. The flow was clear with iron sediment and was of a magnitude of about 5 gpm. A few animal burrows exist in the embankment. There is no evidence that the dam has ever been overtopped nor is there evidence of sliding, settlement, or sinkholes. No toe drains or relief wells were observed.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The primary spillway is located approximately at Sta 3+10 of the dam crest. About 1 foot of the outside of the primary spillway pipe at each end and about 10 feet of the inside of the pipe at the outlet end were observed. Observation of the pipe from the downstream end revealed that the pipe curves upward. A minor amount of rust was observed on the pipe. There was no evidence of leakage into, out of, or around the primary spillway.

d. Geology. The soil on the ridge above the reservoir is formed in loess, and the soil on the slopes is formed in residuum. The soil below the toe of the dam is an alluvial/colluvial soil consisting of silt and clay. Seepage from this alluvium at the approximate rate of 5 gpm was observed in the downstream channel along the base of the embankment.

Outcrops of limestone were observed along both sides of the reservoir approximately five feet above the water. The limestone is massive, light-gray and granular and occurred in 2-3 foot thick beds with occasional shale partings and prominent vertical, widely spaced joints 2 to 3 inches wide. Two sets of vertical joints intersecting at right angles are present in the limestone. The limestone weathers to a buff to tan color. A greenish-gray, sandy micareous shale is present beneath the limestone at the tailwaters of the reservoir. It was soft and blocky and tended to weather into small plates 2 to 3 inches in width.

Samples of the embankment material were taken with an Oakfield sampler. The material at the downstream crest of the embankment consists of 1.3 feet of clayey silt visually classified as a ML material overlying silty clay classified as a CL material. The material near the right abutment consists of 1.0 feet of clayey silt (ML) overlying silty clay (CL). Visual classifications were made in accordance with ASTM D 2488-69. Based on these samples, it is anticipated that the embankment consists of 1 to 2 feet of clayey silt (ML) at the surface and silty clay (CL) throughout the rest of the embankment.

e. Reservoir Area. Erosion has occurred on the embankment at the waterline. There is a minor amount of lake siltation, but the lake bottom can be seen to a depth of 1-1 1/2 feet. No slides of the reservoir banks were observed.

f. Downstream Channel. The channel downstream of the primary spillway outlet pipe is a natural open channel to the original streambed. The streambed runs parallel to the toe of the dam. The streambed is 3-4 feet deep and about 7 feet wide.

3.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control. The absence of riprap on the face of the dam has resulted in wave action erosion of the embankment. If not corrected, wave action will continue to erode the embankment and could lead to slope stability problems. The growth of trees and brush and the uncut grass on the slopes could cause deterioration of the embankment. The roots of trees can loosen the embankment material and also can leave voids through which water can pass. Brush on the dam prevents inspection of the embankment and kills the smaller grasses whose roots are more effective in protecting the surface soil of the slope from erosion. The brush and uncut grass provide habitat for burrowing animals which can damage the embankment. The area of seepage in the creek channel should be monitored in order to determine the source of the flow. Motor bike traffic across the crest of the dam and digging for fishing worms on the front face should be discontinued.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, inflow from springs, evaporation, transpiration, seepage from the reservoir, and overflow through the uncontrolled primary spillway outlet pipe.

4.2 MAINTENANCE OF DAM

No maintenance was evident.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing warning system or preplanned scheme for alerting downstream residents for this dam.

4.5 EVALUATION

A maintenance program should be initiated which would include mowing the grass cover on the embankment in order to discourage animal burrowing. The brush and trees on the embankment should be removed more frequently.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No design data were available.

b. Experience Data. The drainage area and lake surface area are developed from the USGS Kearney SW Quadrangle Map. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The primary spillway appears to be in good condition. The lake level at the time of the inspection (El. 929.0) was at the inlet level and there was a small amount of flow through the pipe. Only the inlet and outlet ends were observable. The spillway pipe discharges with a free outfall into a natural channel. There were no obstructions to flow in the downstream channel.

(2) Spillway discharges do not endanger the integrity of the dam.

d. Overtopping Potential. The spillway will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway will pass 15 percent of the probable maximum flood without overtopping the dam. The spillway will pass the one percent probability flood flow estimated to have a peak outflow of 21 cfs developed by a 24-hour, one percent probability rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the downstream hazard, the appropriate spillway design flood should be 100 percent of the probable maximum flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 1,605 cfs of the total discharge from the reservoir of 1,626 cfs. The estimated duration of overtopping is 11.7 hours with a maximum height of 1.9 feet. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 702 cfs of the total discharge from the reservoir of 723 cfs. The estimated duration of overtopping is 6.5 hours with a maximum height of 1.4 feet. Overtopping for this period of time could jeopardize the embankment.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately three miles downstream of the dam. Within the estimated damage zone are twenty-two

homes, two highways, four buildings, a nursing home, a shopping center, a sewage disposal pond and a railroad. Contents of the estimated downstream damage zone were verified by the inspection team. The City of Liberty controls development in the 100-year floodplain below the dam through a zoning ordinance.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operational records exist.

d. Postconstruction Changes. The year of any rehabilitation is unknown.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservation should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning; and embankment geometry.

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are erosion on the upstream face of the dam, trees on both the upstream and downstream faces, ruts and potholes on the crest, a few animal burrows, seepage in the creek channel downstream of the dam, and holes in the upstream face caused by people digging for fishing worms. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. A program should be developed as soon as possible to monitor at regular intervals the deficiencies described in this report. The remedial measures recommended in paragraph 7.2b should be accomplished in the near future. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Additional Investigation. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require an additional investigation. However, the additional analyses noted in paragraph 2.5.b are necessary for compliance with the guidelines.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. An emergency spillway can be created by excavating the low portion of the crest or by increasing the height of the dam along the remainder of the crest. Otherwise the lake level would

need to be lowered to increase available flood storage in order to pass the spillway design flood.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended and should be implemented under the direction of a professional engineer experienced in the design, construction, and maintenance of earth dams:

(1) Riprap should be placed on the upstream face of the dam at the normal lake level to prevent erosion of the embankment material.

(2) The seepage area noted during the visual inspection should be closely monitored to determine the source of the flow. Any significant changes should be evaluated.

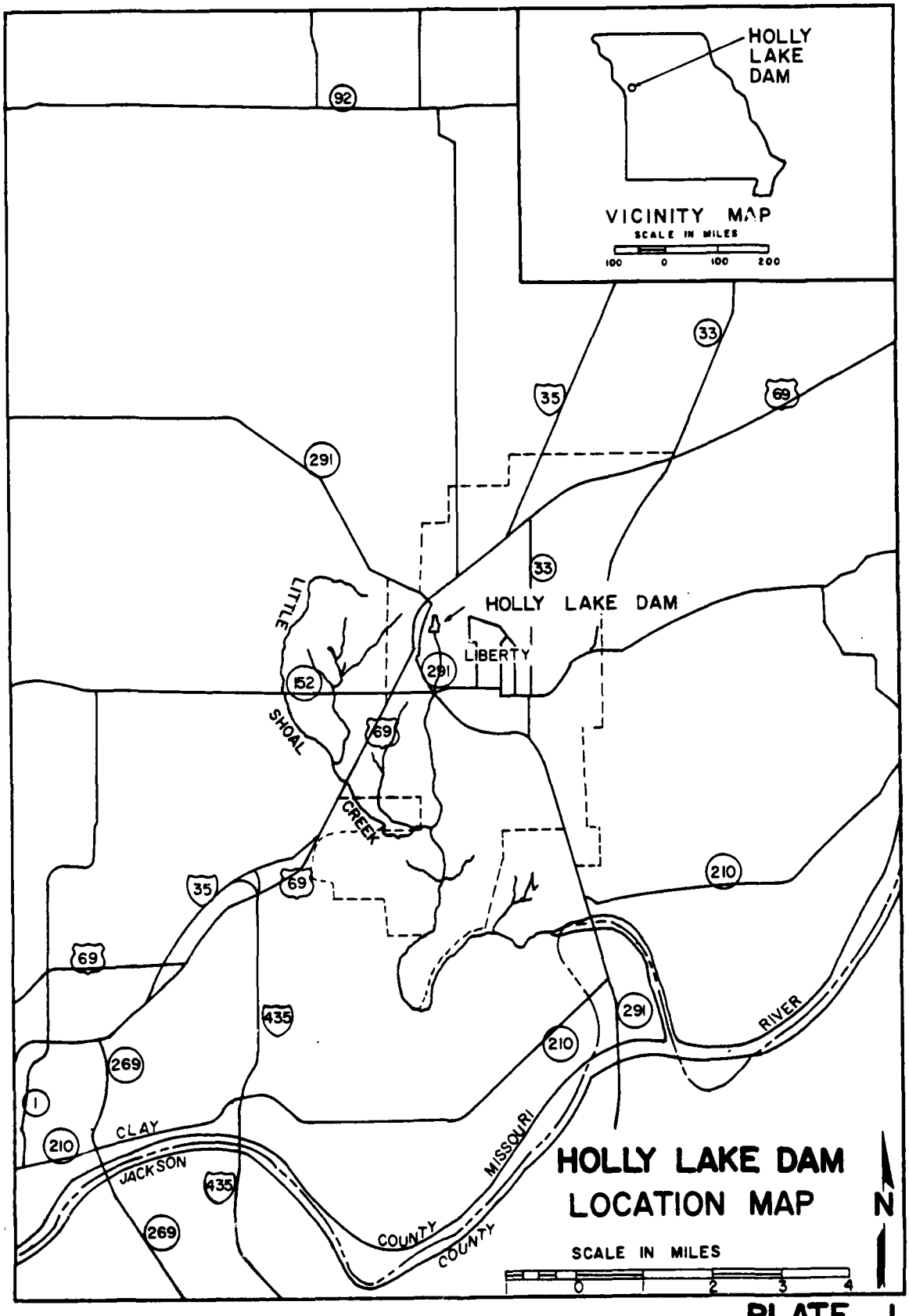
(3) The animal burrows in the embankment should be corrected since they can lead to piping. Control measures should be implemented to discourage increased animal activity in the area. The embankment slope should be monitored during this repair.

(4) The ruts and potholes on the crest and the holes in the front face of the embankment should be repaired. Motor bike traffic across the crest of the dam and digging for fishing worms on the front face should be discontinued.

(5) An improved maintenance program to remove and control the growth of brush and trees on the embankment should be developed. Grass cover on the embankment should be cut periodically.

(6) Seepage and stability analyses should be performed.

(7) A detailed inspection of the dam should be made periodically. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.


HOLLY
LAKE
DAM
VICINITY MAP
SCALE IN MILES
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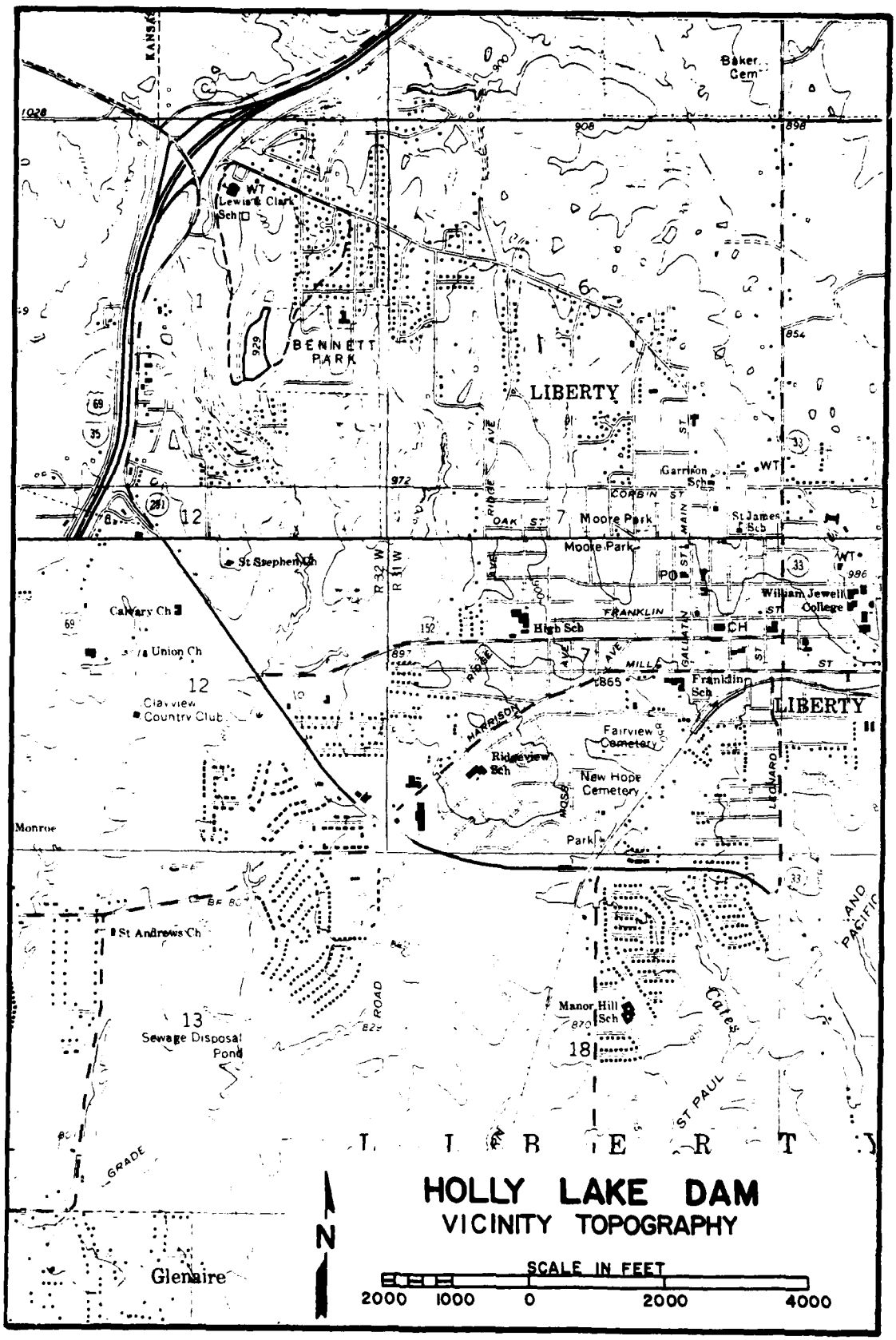
92
33
35
69
291
HOLLY LAKE DAM
LIBERTY
LITTLE
SHOAL
CREEK
152
210
435
269
1
CLAY
JACKSON
COUNTY
COUNTY
MISSOURI
RIVER
HOLLY LAKE DAM
LOCATION MAP
N
SCALE IN MILES
0 2 3 4

PLATE 1



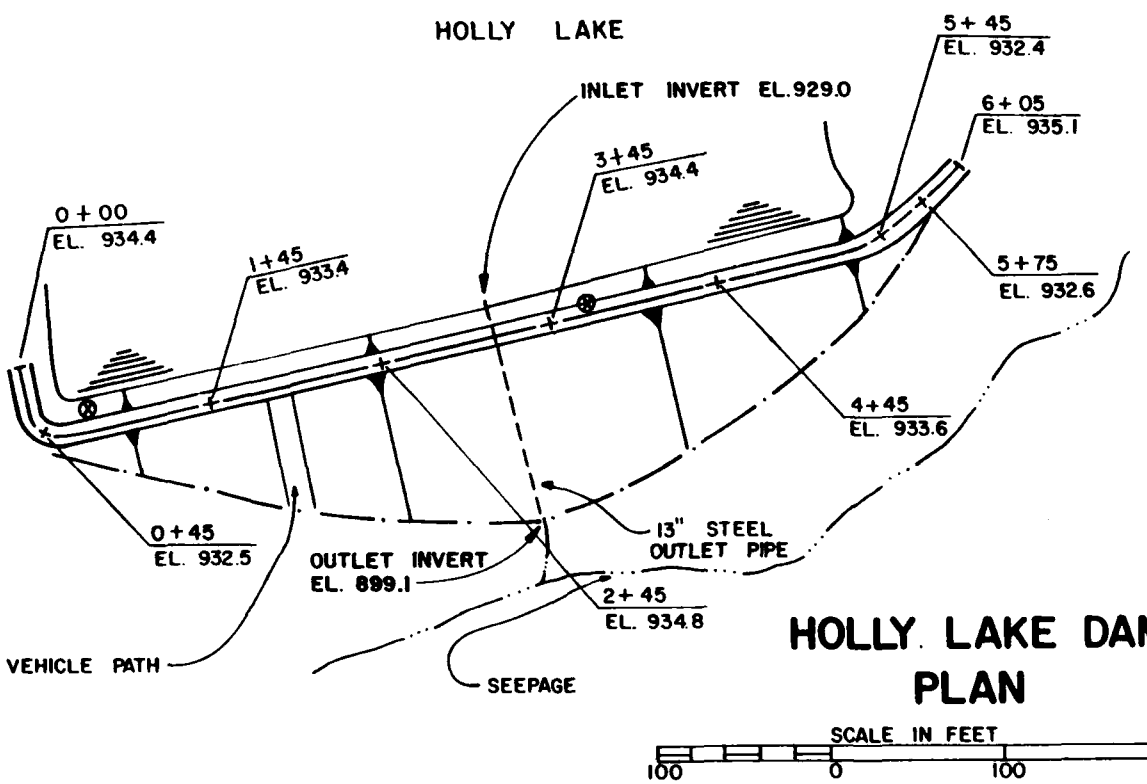
HOLLY LAKE DAM
VICINITY TOPOGRAPHY

PLATE 2

LEGEND

STATION
/ELEVATION

⊗ AUGER BORING



HOLLY LAKE DAM
PLAN

PLATE 3

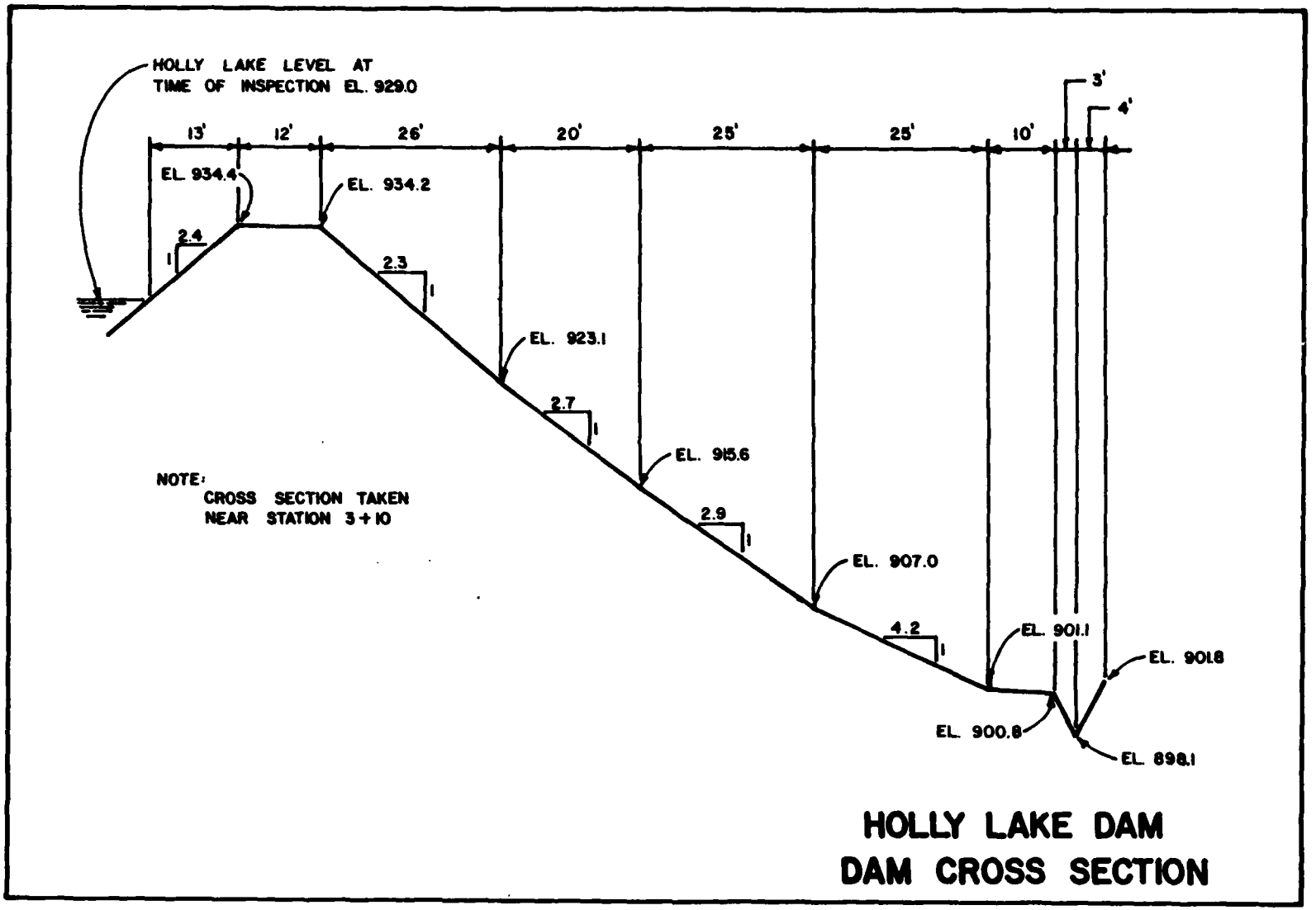


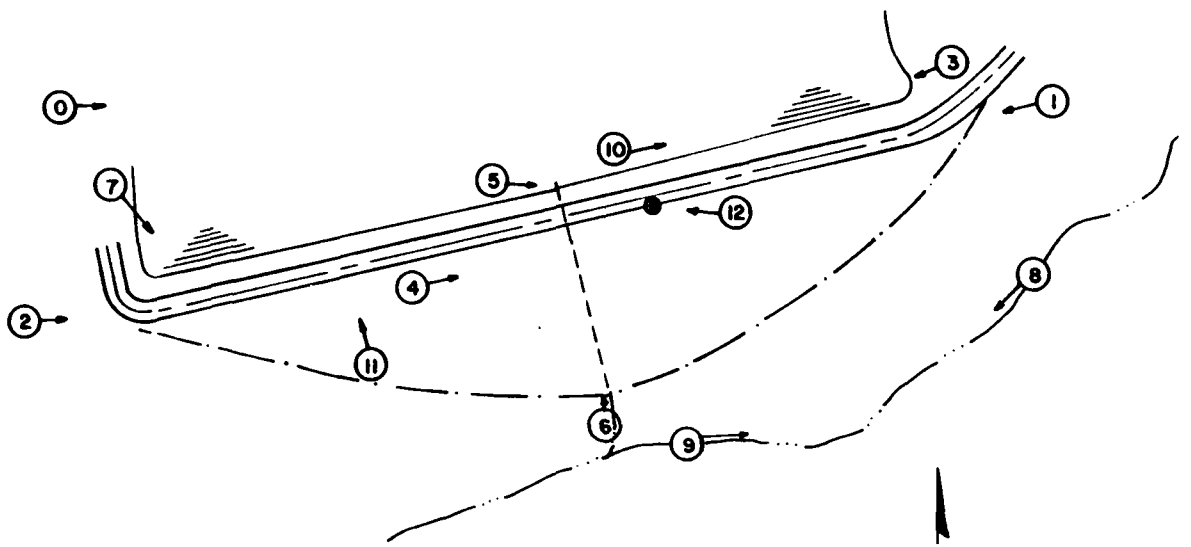
PLATE 4

HOLLY LAKE DAM
DAM CROSS SECTION

LEGEND

(1) PHOTO NO. & DIRECTION

⊕ AUGER BORING



HOLLY LAKE DAM
PHOTO INDEX

PLATE 5

PHOTO 1: CREST OF DAM FROM LEFT ABUTMENT

PHOTO 2: CREST OF DAM FROM RIGHT ABUTMENT

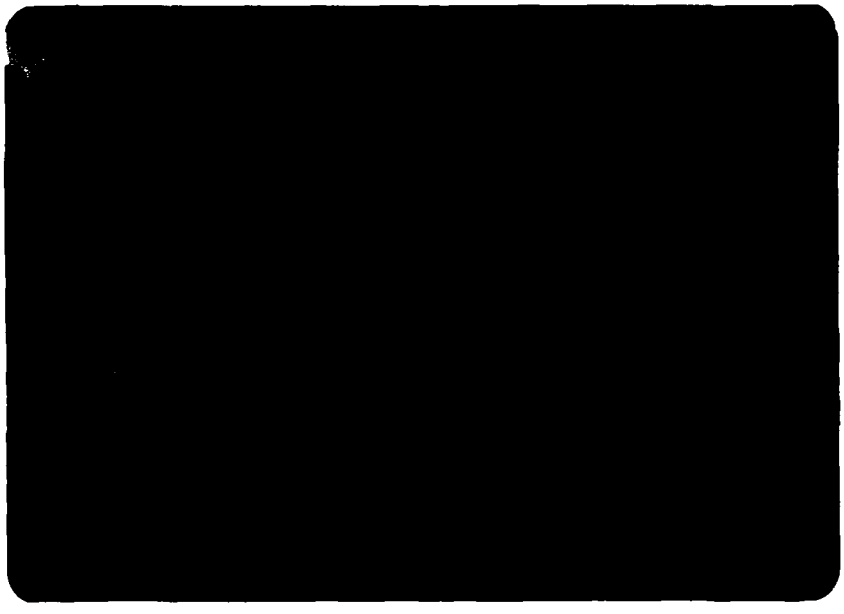


PHOTO 3: UPSTREAM FACE OF DAM

PHOTO 4: TYPICAL DOWNSTREAM SLOPE OF DAM

PHOTO 5: INLET TO PRIMARY SPILLWAY

PHOTO 6: OUTLET TO PRIMARY SPILLWAY

PHOTO 7: CREST OF DAM AT RIGHT ABUTMENT

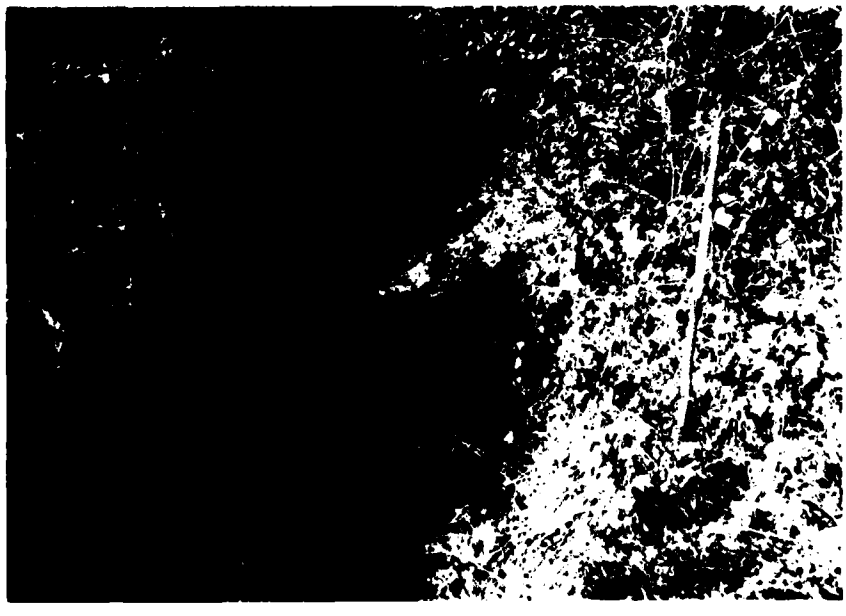


PHOTO 8: CREEK CHANNEL BELOW TOE OF DAM

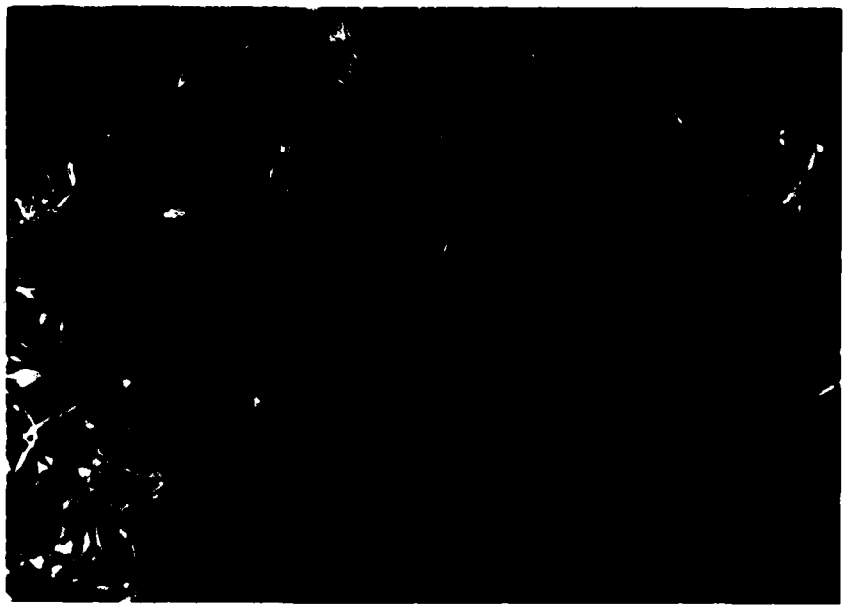


PHOTO 9: SEEPAGE IN CREEK CHANNEL BELOW DAM

PHOTO 10: EROSION OF FACE OF DAM

PHOTO 11: VEHICLE TRACKS UP BACK SLOPE OF DAM

PHOTO 12: SAMPLE OF EMBANKMENT MATERIAL

APPENDIX A

HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs and hydrologic inputs as follows:

a. Twenty-four hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 24.6
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile rainfall	- 130%

b. Drainage area = 81 acres.

c. Time of concentration:

$$T_c = (11.9 \times L^3/H)^{0.385} + L_w/V$$
$$= 0.15 \text{ hours} + 0.01 \text{ hours}$$
$$= 0.16 \text{ hours}$$
$$= 9.5 \text{ minutes}$$

where:

L = 0.39 miles = length of longest watercourse in miles
H = 101 feet = elevation difference in feet
L_w = 1,050 feet = length of lake
V_w = wave velocity = 29 feet per second (2 and 3).

Lag:

$$\text{Lag} = 0.6\ T_c$$
$$= 0.095 \text{ hours (4).}$$

d. The soil associations in this watershed were Knox and Snead (3).

e. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 83 for antecedent moisture condition III and a curve number of 67 for antecedent moisture condition II. Approximately 70% of the drainage area was hydrologic soil group B;

and 30% of the drainage area was hydrologic soil Group D. The land uses in the watershed were 90% timber and 10% urban (4 and 5).

2. Primary spillway release rates were based on the pressure flow through the pipe acting as an orifice.

Orifice equation:

$$Q = Ca[2gH]^{1/2}$$

where:

C = 0.50 = coefficient of discharge
a = 0.92 sq. ft. = net area of the orifice in square feet
g = gravitational acceleration
H = difference between the energy gradient elevation upstream and the tailwater elevation downstream (6)

Discharge rates over the top of the dam were determined by HEC-1 (1) given data describing the embankment crest.

3. The relationship between elevation and storage volume for the reservoir was determined from a contour map of the reservoir area. A planimeter measurement was made of the area enclosed by each contour line. The storage below each elevation was computed by HEC-1 (1) given this area-elevation data.

4. Floods were routed through the spillway using HEC-1, modified Puls to determine the capability of the spillway.

(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.

(2) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.

(3) U.S. Department of Agriculture, Soil Conservation Service, Preliminary Soils Report for Clay County, Missouri.

(4) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.

(5) U.S. Department of Agriculture, Soil Conservation Service, Technical Release No. 55, Urban Hydrology for Small Watersheds, January, 1975.

(6) Horace W. King and Ernest F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw Hill Book Company, 1976.

(7) U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Interpretations and Field Maps, 1980.

(8) Mary H. McCracken, Missouri Division of Geological Survey, Geologic Map of Missouri, 1961.

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
     1                A1MISSOURI DAM INSPECTION PROGRAM
     2                A2ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
     3                A3HOLLY LAKE DAM
     4                B     288       0       5       0       0       0       0       0       0       0
     5                B1      5
     6                J       1       5       1
     7                J1   .05     .10     .15     .20     .25      .3     .35      .5      1.
     8                K       0       1                               3       1
     9                K1    HOLLY LAKE (24 HR. PROBABLE MAXIMUM RUNOFF)
    10                M       1       2    .127                       1
    11                P              24.60     101     120     130
    12                Y                                                       -1      -83
    13                W2            .0948
    14                X                       1
    15                K       1       2                                       1
    16                K1    ROUTING THROUGH SPILLWAY
    17                Y                                       1       1
    18                Y1      1                                               -929.   -1
    19                Y4   929.  930.1   931.1   932.1   933.1   934.1   935.1   936.1   937.1   938.1
    20                Y4 938.1  940.1
    21                Y5      0.      2.      21.     21.     21.     21.     22.     22.     23.     23.
    22                Y5     23.     24.
    23                $A0.     6.33    8.13    15.36
    24                $E909.   929.    940.    960.
    25                $1929.
    26                $D932.4
    27                $L0.     98.     163.    222.    298.    442.    613.    636.    656.    690.
    28                $V932.4 932.7   933.0   933.3   933.6   934.2   934.8   935.4   936.0   936.9
    29                K      99
```

RUN DATE: 06/11/80.
TIME: 11.58.)

MISSOURI DAM INSPECTION PROGRAM
ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
HOLLY LAKE DAM

JOB SPECIFICATION

NQ	NHR	NPLN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS= .05 .10 .15 .20 .25 .30 .35 .50 1.00

********** *********** *********** *********** **********

SUB-AREA RUNOFF COMPUTATION

HOLLY LAKE (24 HR. PROBABLE MAXIMUM RUNOFF)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	3	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.13	0.00	.13	1.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	24.60	101.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-83.00	0.00	0.00

CURVE NO = -83.00 WETNESS = -1.00 EFFECT CN = 83.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .09

RECESSION DATA
STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

TIME INCREMENT TOO LARGE--(NHR IS GT LAG/2)

UNIT HYDROGRAPH 8 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .09 VOL= 1.00
305. 413. 167. 62. 23. 9. 3. 1.

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.21	.19	.02	99.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.19	.02	153.

STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

ME INCREMENT TOO LARGE--(NHR IS GT LAG/2)

UNIT HYDROGRAPH 8 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .09 VOL= 1.00

305. 413. 167. 62. 23. 9. 3. 1.

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.21	.19	.02	99.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.19	.02	153.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.19	.01	176.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.19	.01	185.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.19	.01	189.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.19	.01	190.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.20	.01	191.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.20	.01	192.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.20	.01	193.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.20	.01	193.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.21	.20	.01	194.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.21	.20	.01	194.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.25	.24	.01	206.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.25	.24	.01	223.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.25	.24	.01	230.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.25	.24	.01	233.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.25	.24	.01	235.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.25	.24	.01	235.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.25	.24	.01	236.
1.01	1.40	20	.01	0.00	.01	0.	1.01	13.40	164	.25	.24	.01	236.
1.01	1.45	21	.01	0.00	.01	0.	1.01	13.45	165	.25	.24	.01	237.
1.01	1.50	22	.01	0.00	.01	0.	1.01	13.50	166	.25	.24	.01	237.
1.01	1.55	23	.01	0.00	.01	0.	1.01	13.55	167	.25	.24	.01	237.
1.01	2.00	24	.01	0.00	.01	0.	1.01	14.00	168	.25	.24	.01	238.
1.01	2.05	25	.01	0.00	.01	0.	1.01	14.05	169	.31	.30	.01	256.
1.01	2.10	26	.01	0.00	.01	0.	1.01	14.10	170	.31	.30	.01	282.
1.01	2.15	27	.01	0.00	.01	0.	1.01	14.15	171	.31	.30	.01	292.
1.01	2.20	28	.01	0.00	.01	0.	1.01	14.20	172	.31	.30	.01	296.
1.01	2.25	29	.01	0.00	.01	0.	1.01	14.25	173	.31	.30	.01	298.
1.01	2.30	30	.01	.00	.01	0.	1.01	14.30	174	.31	.30	.01	299.
1.01	2.35	31	.01	.00	.01	0.	1.01	14.35	175	.31	.30	.01	299.
1.01	2.40	32	.01	.00	.01	0.	1.01	14.40	176	.31	.30	.01	299.
1.01	2.45	33	.01	.00	.01	0.	1.01	14.45	177	.31	.31	.01	300.
1.01	2.50	34	.01	.00	.01	0.	1.01	14.50	178	.31	.31	.01	300.
1.01	2.55	35	.01	.00	.01	1.	1.01	14.55	179	.31	.31	.01	300.
1.01	3.00	36	.01	.00	.01	1.	1.01	15.00	180	.31	.31	.00	300.
1.01	3.05	37	.01	.00	.01	1.	1.01	15.05	181	.19	.19	.00	264.
1.01	3.10	38	.01	.00	.01	1.	1.01	15.10	182	.38	.37	.01	271.
1.01	3.15	39	.01	.00	.01	1.	1.01	15.15	183	.38	.37	.01	328.
1.01	3.20	40	.01	.00	.01	1.	1.01	15.20	184	.57	.56	.01	409.
1.01	3.25	41	.01	.00	.01	2.	1.01	15.25	185	.66	.65	.01	523.
1.01	3.30	42	.01	.00	.01	2.	1.01	15.30	186	1.61	1.59	.02	862.
1.01	3.35	43	.01	.00	.01	2.	1.01	15.35	187	2.64	2.62	.02	1611.
1.01	3.40	44	.01	.00	.01	2.	1.01	15.40	188	1.04	1.03	.01	1719.
1.01	3.45	45	.01	.00	.01	2.	1.01	15.45	189	.66	.66	.00	1184.
1.01	3.50	46	.01	.00	.01	2.	1.01	15.50	190	.57	.56	.00	823.
1.01	3.55	47	.01	.00	.01	2.	1.01	15.55	191	.38	.38	.00	597.
1.01	4.00	48	.01	.00	.01	3.	1.01	16.00	192	.38	.38	.00	456.
1.01	4.05	49	.01	.00	.01	3.	1.01	16.05	193	.29	.29	.00	374.
1.01	4.10	50	.01	.00	.01	3.	1.01	16.10	194	.29	.29	.00	316.
1.01	4.15	51	.01	.00	.01	3.	1.01	16.15	195	.29	.29	.00	295.
1.01	4.20	52	.01	.00	.01	3.	1.01	16.20	196	.29	.29	.00	287.

1.01	3.25	41	.01	.00	.01	2.	1.01	15.25	185	.66	.65	.01	523.
1.01	3.30	42	.01	.00	.01	2.	1.01	15.30	186	1.61	1.59	.02	882.
1.01	3.35	43	.01	.00	.01	2.	1.01	15.35	187	2.64	2.62	.02	1611.
1.01	3.40	44	.01	.00	.01	2.	1.01	15.40	188	1.74	1.03	.01	1719.
1.01	3.45	45	.01	.00	.01	2.	1.01	15.45	189	.66	.66	.00	1184.
1.01	3.50	46	.01	.00	.01	2.	1.01	15.50	190	.57	.56	.00	823.
1.01	3.55	47	.01	.00	.01	2.	1.01	15.55	191	.38	.38	.00	597.
1.01	4.00	48	.01	.00	.01	3.	1.01	16.00	192	.38	.38	.00	456.
1.01	4.05	49	.01	.00	.01	3.	1.01	16.05	193	.29	.29	.00	374.
1.01	4.10	50	.01	.00	.01	3.	1.01	16.10	194	.29	.29	.00	316.
1.01	4.15	51	.01	.00	.01	3.	1.01	16.15	195	.29	.29	.00	295.
1.01	4.20	52	.01	.00	.01	3.	1.01	16.20	196	.29	.29	.00	287.
1.01	4.25	53	.01	.00	.01	3.	1.01	16.25	197	.29	.29	.00	284.
1.01	4.30	54	.01	.00	.01	3.	1.01	16.30	198	.29	.29	.00	284.
1.01	4.35	55	.01	.00	.01	3.	1.01	16.35	199	.29	.29	.00	283.
1.01	4.40	56	.01	.00	.01	3.	1.01	16.40	200	.29	.29	.00	283.
1.01	4.45	57	.01	.00	.01	4.	1.01	16.45	201	.29	.29	.00	283.
1.01	4.50	58	.01	.00	.01	4.	1.01	16.50	202	.29	.29	.00	283.
1.01	4.55	59	.01	.00	.01	4.	1.01	16.55	203	.29	.29	.00	283.
1.01	5.00	60	.01	.00	.01	4.	1.01	17.00	204	.29	.29	.00	284.
1.01	5.05	61	.01	.00	.01	4.	1.01	17.05	205	.23	.23	.00	265.
1.01	5.10	62	.01	.00	.01	4.	1.01	17.10	206	.23	.23	.00	239.
1.01	5.15	63	.01	.00	.01	4.	1.01	17.15	207	.23	.23	.00	229.
1.01	5.20	64	.01	.00	.01	4.	1.01	17.20	208	.23	.23	.00	225.
1.01	5.25	65	.01	.00	.01	4.	1.01	17.25	209	.23	.23	.00	224.
1.01	5.30	66	.01	.00	.01	5.	1.01	17.30	210	.23	.23	.00	223.
1.01	5.35	67	.01	.00	.01	5.	1.01	17.35	211	.23	.23	.00	223.
1.01	5.40	68	.01	.00	.01	5.	1.01	17.40	212	.23	.23	.00	223.
1.01	5.45	69	.01	.01	.01	5.	1.01	17.45	213	.23	.23	.00	223.
1.01	5.50	70	.01	.01	.01	5.	1.01	17.50	214	.23	.23	.00	223.
1.01	5.55	71	.01	.01	.01	5.	1.01	17.55	215	.23	.23	.00	223.
1.01	6.00	72	.01	.01	.01	5.	1.01	18.00	216	.23	.23	.00	223.
1.01	6.05	73	.06	.03	.04	12.	1.01	18.05	217	.02	.02	.00	160.
1.01	6.10	74	.06	.03	.04	21.	1.01	18.10	218	.02	.02	.00	75.
1.01	6.15	75	.06	.03	.04	26.	1.01	18.15	219	.02	.02	.00	40.
1.01	6.20	76	.06	.03	.03	28.	1.01	18.20	220	.02	.02	.00	27.
1.01	6.25	77	.06	.03	.03	30.	1.01	18.25	221	.02	.02	.00	23.
1.01	6.30	78	.06	.03	.03	32.	1.01	18.30	222	.02	.02	.00	21.
1.01	6.35	79	.06	.04	.03	33.	1.01	18.35	223	.02	.02	.00	20.
1.01	6.40	80	.06	.04	.03	35.	1.01	18.40	224	.02	.02	.00	20.
1.01	6.45	81	.06	.04	.03	36.	1.01	18.45	225	.02	.02	.00	20.
1.01	6.50	82	.06	.04	.03	37.	1.01	18.50	226	.02	.02	.00	20.
1.01	6.55	83	.06	.04	.02	38.	1.01	18.55	227	.02	.02	.00	20.
1.01	7.00	84	.06	.04	.02	39.	1.01	19.00	228	.02	.02	.00	20.
1.01	7.05	85	.06	.04	.02	40.	1.01	19.05	229	.02	.02	.00	20.
1.01	7.10	86	.06	.04	.02	41.	1.01	19.10	230	.02	.02	.00	20.
1.01	7.15	87	.06	.04	.02	42.	1.01	19.15	231	.02	.02	.00	20.
1.01	7.20	88	.06	.04	.02	43.	1.01	19.20	232	.02	.02	.00	20.
1.01	7.25	89	.06	.04	.02	43.	1.01	19.25	233	.02	.02	.00	20.
1.01	7.30	90	.06	.05	.02	44.	1.01	19.30	234	.02	.02	.00	20.
1.01	7.35	91	.06	.05	.02	45.	1.01	19.35	235	.02	.02	.00	20.
1.01	7.40	92	.06	.05	.02	45.	1.01	19.40	236	.02	.02	.00	20.
1.01	7.45	93	.06	.05	.02	46.	1.01	19.45	237	.02	.02	.00	20.
1.01	7.50	94	.06	.05	.02	47.	1.01	19.50	238	.02	.02	.00	20.
1.01	7.55	95	.06	.05	.02	47.	1.01	19.55	239	.02	.02	.00	20.
1.01	8.00	96	.06	.05	.02	48.	1.01	20.00	240	.02	.02	.00	20.
1.01	8.05	97	.06	.05	.02	48.	1.01	20.05	241	.02	.02	.00	20.
1.01	8.10	98	.06	.05	.01	49.	1.01	20.10	242	.02	.02	.00	20.
1.01	8.15	99	.06	.05	.01	49.	1.01	20.15	243	.02	.02	.00	20.
1.01	8.20	100	.06	.05	.01	50.	1.01	20.20	244	.02	.02	.00	20.
1.01	8.25	101	.06	.05	.01	50.	1.01	20.25	245	.02	.02	.00	20.
1.01	8.30	102	.06	.05	.01	50.	1.01	20.30	246	.02	.02	.00	20.

1.01	8.00	96	.06	.05	.02	48.	1.01	20.00	240	.02	.02	.00	20.
1.01	8.05	97	.06	.05	.02	48.	1.01	20.05	241	.02	.02	.00	20.
1.01	8.10	98	.06	.05	.01	49.	1.01	20.10	242	.02	.02	.00	20.
1.01	8.15	99	.06	.05	.01	49.	1.01	20.15	243	.02	.02	.00	20.
1.01	8.20	100	.06	.05	.01	50.	1.01	20.20	244	.02	.02	.00	20.
1.01	8.25	101	.06	.05	.01	50.	1.01	20.25	245	.02	.02	.00	20.
1.01	8.30	102	.06	.05	.01	50.	1.01	20.30	246	.02	.02	.00	20.
1.01	8.35	103	.06	.05	.01	51.	1.01	20.35	247	.02	.02	.00	20.
1.01	8.40	104	.06	.05	.01	51.	1.01	20.40	248	.02	.02	.00	20.
1.01	8.45	105	.06	.05	.01	51.	1.01	20.45	249	.02	.02	.00	20.
1.01	8.50	106	.06	.05	.01	52.	1.01	20.50	250	.02	.02	.00	20.
1.01	8.55	107	.06	.05	.01	52.	1.01	20.55	251	.02	.02	.00	20.
1.01	9.00	108	.06	.05	.01	52.	1.01	21.00	252	.02	.02	.00	20.
1.01	9.05	109	.06	.05	.01	53.	1.01	21.05	253	.02	.02	.00	20.
1.01	9.10	110	.06	.05	.01	53.	1.01	21.10	254	.02	.02	.00	20.
1.01	9.15	111	.06	.05	.01	53.	1.01	21.15	255	.02	.02	.00	20.
1.01	9.20	112	.06	.05	.01	54.	1.01	21.20	256	.02	.02	.00	20.
1.01	9.25	113	.06	.06	.01	54.	1.01	21.25	257	.02	.02	.00	20.
1.01	9.30	114	.06	.06	.01	54.	1.01	21.30	258	.02	.02	.00	20.
1.01	9.35	115	.06	.06	.01	54.	1.01	21.35	259	.02	.02	.00	20.
1.01	9.40	116	.06	.06	.01	55.	1.01	21.40	260	.02	.02	.00	20.
1.01	9.45	117	.06	.06	.01	55.	1.01	21.45	261	.02	.02	.00	20.
1.01	9.50	118	.06	.06	.01	55.	1.01	21.50	262	.02	.02	.00	20.
1.01	9.55	119	.06	.06	.01	55.	1.01	21.55	263	.02	.02	.00	20.
1.01	10.00	120	.06	.06	.01	55.	1.01	22.00	264	.02	.02	.00	20.
1.01	10.05	121	.06	.06	.01	56.	1.01	22.05	265	.02	.02	.00	20.
1.01	10.10	122	.06	.06	.01	56.	1.01	22.10	266	.02	.02	.00	20.
1.01	10.15	123	.06	.06	.01	56.	1.01	22.15	267	.02	.02	.00	20.
1.01	10.20	124	.06	.06	.01	56.	1.01	22.20	268	.02	.02	.00	20.
1.01	10.25	125	.06	.06	.01	56.	1.01	22.25	269	.02	.02	.00	20.
1.01	10.30	126	.06	.06	.01	56.	1.01	22.30	270	.02	.02	.00	20.
1.01	10.35	127	.06	.06	.01	57.	1.01	22.35	271	.02	.02	.00	20.
1.01	10.40	128	.06	.06	.01	57.	1.01	22.40	272	.02	.02	.00	20.
1.01	10.45	129	.06	.06	.01	57.	1.01	22.45	273	.02	.02	.00	20.
1.01	10.50	130	.06	.06	.01	57.	1.01	22.50	274	.02	.02	.00	20.
1.01	10.55	131	.06	.06	.01	57.	1.01	22.55	275	.02	.02	.00	20.
1.01	11.00	132	.06	.06	.01	57.	1.01	23.00	276	.02	.02	.00	20.
1.01	11.05	133	.06	.06	.01	57.	1.01	23.05	277	.02	.02	.00	20.
1.01	11.10	134	.06	.06	.01	58.	1.01	23.10	278	.02	.02	.00	20.
1.01	11.15	135	.06	.06	.01	58.	1.01	23.15	279	.02	.02	.00	20.
1.01	11.20	136	.06	.06	.01	58.	1.01	23.20	280	.02	.02	.00	20.
1.01	11.25	137	.06	.06	.01	58.	1.01	23.25	281	.02	.02	.00	20.
1.01	11.30	138	.06	.06	.01	58.	1.01	23.30	282	.02	.02	.00	20.
1.01	11.35	139	.06	.06	.01	58.	1.01	23.35	283	.02	.02	.00	20.
1.01	11.40	140	.06	.06	.01	58.	1.01	23.40	284	.02	.02	.00	20.
1.01	11.45	141	.06	.06	.01	58.	1.01	23.45	285	.02	.02	.00	20.
1.01	11.50	142	.06	.06	.01	58.	1.01	23.50	286	.02	.02	.00	20.
1.01	11.55	143	.06	.06	.01	59.	1.01	23.55	287	.02	.02	.00	20.
1.01	12.00	144	.06	.06	.01	59.	1.02	0.00	288	.02	.02	.00	20.
									SUM	31.98	29.65	2.33	29114.
										(812.)(	753.)(	59.)(	824.42)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1719.	331.	101.	101.	29110.
CMS	49.	9.	3.	3.	824.
INCHES		24.25	29.61	29.61	29.61
MM		615.87	752.20	752.20	752.20
AC-FT		164.	200.	200.	200.
THOUS CU M		202.	247.	247.	247.

INCHES	24.25	29.61	29.61	29.61
MM	615.87	752.20	752.20	752.20
AC-FT	164.	200.	200.	200.
THOUS CU M	202.	247.	247.	247.

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HYDROGRAPH ROUTING

ROUTING THROUGH SPILLWAY

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPPT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-929.	-1

STAGE	929.00	930.10	931.10	932.10	933.10	934.10	935.10	936.10	937.10	938.10
	938.10	940.10								
FLOW	0.00	2.00	21.00	21.00	21.00	21.00	22.00	22.00	23.00	23.00
	23.00	24.00								

SURFACE AREA=	0.	6.	8.	15.
CAPACITY=	0.	42.	122.	353.
ELEVATION=	909.	929.	940.	960.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
929.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
932.4	0.0	0.0	0.

CREST LENGTH AT OR BELOW	0.	98.	163.	222.	298.	442.	613.	636.	656.	690.
ELEVATION	932.4	932.7	933.0	933.3	933.6	934.2	934.8	935.4	936.0	936.9

STATION 2, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

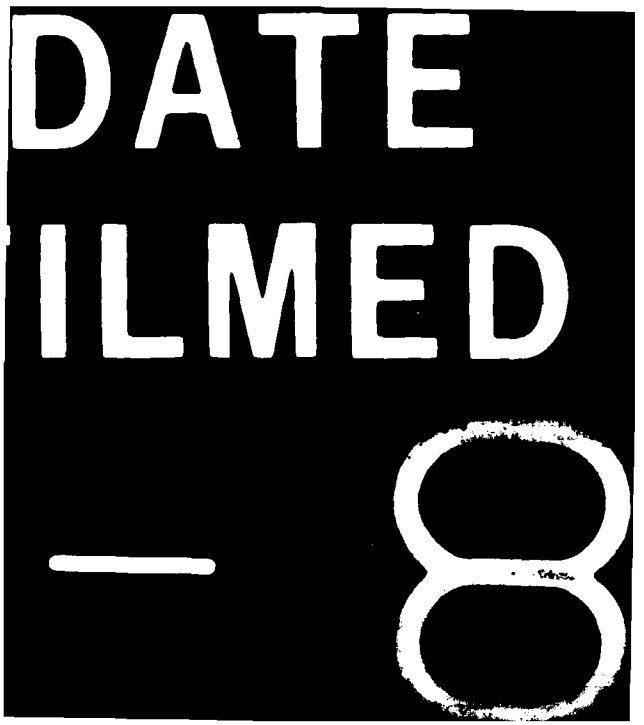
OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1 .05	RATIO 2 .10	RATIO 3 .15	RATIO 4 .20	RATIO 5 .25	RATIO 6 .30	RATIO 7 .35	RATIO 8 .50	RATIO 9 1.00
HYDROGRAPH AT	1	.13	1	86.	172.	258.	344.	430.	516.	602.	859.	1719.
	(	.33)	(	2.43)(	4.87)(	7.30)(	9.73)(	12.17)(	14.60)(	17.04)(	24.34)(	48.67)
ROUTED TO	2	.13	1	6.	21.	21.	56.	181.	360.	484.	723.	1626.
	(	.33)	(	.17)(	.59)(	.59)(	1.59)(	5.12)(	10.20)(	13.70)(	20.48)(	46.05)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	929.00	929.00	932.40
STORAGE	42.	42.	65.
OUTFLOW	0.	0.	21.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	930.31	0.00	51.	6.	0.00	18.08	0.00
.10	931.16	0.00	56.	21.	0.00	16.67	0.00
.15	932.33	0.00	64.	21.	0.00	15.58	0.00
.20	932.79	.39	67.	56.	3.67	17.00	0.00
.25	933.12	.72	70.	181.	4.00	15.83	0.00
.30	933.40	1.00	72.	360.	4.33	15.75	0.00
.35	933.54	1.14	73.	484.	5.08	15.75	0.00
.50	933.76	1.36	74.	723.	6.50	15.75	0.00
1.00	934.32	1.92	78.	1626.	11.75	15.67	0.00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